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ABSTRACT

Issues of equity assume a position of prominence as they relate to the young child's emerging mathematical understandings, the development of scientific thinking and problem solving skills, and potential technological literacies. This paper discusses the key issues of equity for culturally and linguistically diverse children and impoverished children with respect to math, science and technological education in preschool, and considers the role of effective teaching in contributing to greater equity. The discussion focuses on two themes that illustrate both the problems and potentials of early childhood programs to address equity in math, science and technology: educational equity in an inequitable society and equity in inclusive early childhood classrooms. Finally, the article considers the challenge of equity from a more optimistic point of view based on recent advances in the understanding of how children learn and a reconceptualization of the early childhood curriculum. (JPB)

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PLAYING FAIR AND SQUARE: ISSUES OF EQUITY IN PRESCHOOL MATH, SCIENCE, AND TECHNOLOGY

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Issues of Equity in Preschool Math, Science, and Technology

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The period of early childhood is a time in which children's development is especially ripe for the enhancement of numerous social, emotional, and cognitive capacities. Contemporary research also confirms that experiences which take place during the three-to-five year age period are significant precursors to children's subsequent learning and school achievement. Unfortunately, the child's readiness to learn also includes, by definition, a vulnerability to early experiences, including both their presence and their absence. While some variation in children's learning and development is the result of purposeful choices made by parents and teachers, other differences result from lack of opportunity, motivation, and/or understanding. Research on preschool children's knowledge, skills, and dispositions in math, science, and technology has consistently demonstrated differences in children's learning as a function of gender, cultural and linguistic factors, and developmental characteristics. The set of differences associated with educational inequities serves as the focus for this paper.

While early childhood educators have often questioned the appropriateness of "too-early" instruction, recent research and classroom practice validate the premise that educational opportunities associated with these domains are not only highly feasible but, if done right, can contribute to children's learning and development in other areas as well. Thus the debate has shifted from a question of *whether* or *when* to one of ***how?*** Issues of equity assume a position of prominence as they relate to the young child's emerging mathematical understandings, the development of scientific thinking and problem solving skills, and potential technological

literacies. The challenge to be addressed in this paper is twofold:

(1) What are the key issues of equity with respect to math, science, and technological education in the preschool age period?

(2) How can more effective teaching contribute to greater equity, not only in those specific domains, but within the classroom and the larger society as well?

These questions are considerably more complex than can be fully addressed in this paper. The following discussion focuses on two themes that illustrate both the problems and the potentials of early childhood programs to address equity in math, science, and technology: *educational equity in an inequitable society* and *equity in inclusive early childhood classrooms.*

Placing Educational Inequities in Context

Children's development and learning are influenced and interpreted by the larger sociocultural and political context. Comparative studies support the premise of cultural diversity in beliefs regarding children's needs and abilities as well as educational experiences deemed appropriate for optimal development (c.f., studies on Japanese child care and early education by Lewis, 1995). Beatty's recent (1995) analysis of the history of preschool education in the U.S. joins research on early intervention in other nations (Woodhead, 1996) to confirm a dual premise of diversity in (a) perceptions of quality early childhood programs across cultures and (b) accessibility to early childhood programs within cultures. The notion of *diversity as adversity* is particularly relevant as it pertains to unequal and inequitable learning opportunities for young children in contemporary American society (New & Mallory, 1996).

The purpose of American educational institutions for many is to "follow, reflect, and

reproduce the nature of the society in which they exist" (Oakes, 1985, p. 200). Thus, U.S. schools and their curricula have historically promoted autonomy and individual competence, an educational agenda that has placed some children at significantly greater disadvantage than others. In spite of numerous initiatives at the national level over the past three decades that have targeted diverse populations for more equitable treatment, the contrast between some children's educational opportunities and those available to others remains stark. Throughout the twentieth century, discrepancies in young children's educational opportunities have been documented as a function of their membership in racially, culturally, and linguistically diverse populations, with still other differences associated with gender and developmental diversity. Among the most glaring of such discrepancies is children's unequal access to high quality early childhood educational programs in the preschool age period.

The U.S. is unique among industrialized nations in its failure to systematically provide some form of educational opportunity for all young children in the three- to five-year age period. Adhering to the view that the responsibility for the very young child is familial and private rather than social and public, existing services are typically based on deficit interpretations of either the children or their families. Since inception, such educational services have been remarkably inadequate to the task. Issues of funding and financing high quality early childhood programs dominate the discussion among policy makers and early childhood professionals. As we approach the end of the twentieth century, fewer than half of American children ages three-to five have access to affordable and high quality early childhood programs. It is essential to place discussions of equity in math, science, and technology within this larger social, political, and economic context. Joining the claim of inadequate coverage of programs is the possibility that the

nature of the field's targeted programs may "exacerbate the very problems they were designed to ameliorate" (New & Mallory, 1996, p. 150). Early intervention programs' segregated nature precludes experiences with children of diverse interests and abilities and typically emphasize select aspects of development, often at the expense of cognitive or preacademic gains.

Evidence of inequities within the larger society is apparent as soon as children enter a classroom. Among those fortunate enough to have access to a high quality preschool or kindergarten program that is not limited to a targeted population, the diversity among children will likely reflect many of the prejudices and the potentials of the larger society. Some children will have had numerous opportunities to visit science museums, play with tanagrams on the living room floor, and experiment with the technological mouse attached to their family computer. They will have acquired a vocabulary for discussing their ideas and experiences in these domains; they may also have learned a great deal about the role of and value assigned to such knowledge in the larger adult society. Other children enter into early childhood settings in the hope that they, too, will learn the skills and acquire the concepts deemed necessary for productive and meaningful participation in the larger world. For some of these children, however, there will have been little or no exposure to the tools or the talk of mathematical or scientific endeavors. Their insistence that a mouse is an inhabitant of their family's basement will be a source of amusement to other children "in the know." Their lack of familiarity with contemporary technological tools and discourse may or may not lead to appropriate educational opportunities, depending on a number of key factors that influence what happens inside the classroom.

Inequities on the Inside

The field of early childhood began addressing issues of racism and sexism in the teaching

of young children long before the war on poverty and the multicultural education movement (c.f., Dewey, 1911; Goodman, 1952). And yet, when children arrive at public school settings, they are often assigned to readiness classses based on perceptions of so-called risk indicators, including socio-cultural or economic characteristics (Oakes, 1985). Tracking of this sort perpetuates class and racial inequalities of American society; it also furthers the divide between children excluded from versus those invited to participate in other models of education, including gifted and talented programs where an emphasis on mathematical knowledge, scientific endeavors, and technological literacy is almost guaranteed. These inequalities in the resources and programs available in the preschool period increase the likelihood that official bodies of high-status knowledge and ways of thinking remain the property of select groups of children and their families.

In response to this structural inequity, the last two decades have witnessed a steady increase in publications to assist teachers in responding more equitably to diverse populations of young children (c.f., Derman-Sparks, 1989; Kendell, 1996), amid efforts to create more inclusive and equitable educational programs for children with developmental differences and other special needs (Mallory, 1988). In short, there is much for the field to be proud of. And yet key features of the field of early childhood may inadvertently exacerbate inequities in children's learning in the areas of math, science, and technology, including teacher attitudes regarding diversity; teachers' personal and professional knowledge of math, science, and technology; and teacher beliefs about how children learn. Perhaps the most controversial is that of establishing fair, feasible, and relevant educational goals for diverse populations of young children.

From Deficits to Deference

Adult images of children have historically defined the parameters and prerogatives of child care

and early education. Thus teacher interpretations of the significance of differences among and between children directly influence curriculum goals and strategies. Teacher beliefs about the malleability of such differences also influence their responses to children. Such beliefs support practices that include, for example, lesser expectations for girls to participate in scientific problem solving. The complexity of this issue cannot be overstated. Put simply, in their commitment to the multicultural, anti-sexist, and inclusive education movements, early childhood educators may have miscalculated the effect on children's development in emphasizing the value and legitimacy of children's differences over their need for common skills and understandings.

Throughout the last several decades, the maxim *different strokes for different folks* has supported educational practices which respond to children's individual differences and family lifestyles. It is difficult to find fault with a pedagogy that is grounded in knowledge about and respect for children and their families. And yet, if implemented uncritically, this interpretation of difference can further exacerbate inequities in children's learning. At the least, this interpretation presents challenges in responding to another principle deemed essential to an education for a democratic pluralistic society--that all children are entitled to gain access to the skills and knowledge regarded as social capital in the dominant society (Delpit, 1995). This maxim also underestimates the role and the responsibility of teachers in *changing* rather than *deferring to* patterns of work, play, and social behavior that are disadvantageous to some children.

This concept of deference may be found in early childhood programs which adhere to a multicultural philosophy of learning about and responding to children's family backgrounds and individual learning styles and abilities. Even as teachers strive to create a more inclusive educational environment that represents the lives and lifestyles of all the children in the class

rather than just a few, the notion of *deference* is used when this acknowledgement of child characteristics becomes an implicit *acceptance* of disappointments in educational outcomes. This notion of deference is found when teachers utilize science and technology primarily as a means of attracting the attention of otherwise disengaged learners, or as an occasion to utilize children with prior knowledge as "class experts" rather than as means to promote the knowledge and literacies of all children. Even the kinds of questions teachers ask vary as a function of teacher expectation of competence, for example, when boys are more often called upon for complex explanations of mechanical and conceptual concerns while girls are asked to share "facts."

A non-critical acceptance of expected variation in children's interests or abilities does little to modify that variation or reduce social inequities. This concept of deference also reflects some early childhood teachers' tendency to respond more systematically to children's social and behavioral developmental needs rather than their intellectual ones. Variations in classroom practices as a function of gender, disability, or family background are similar in intent and outcome to many of those described previously. When sensitivity to children's individual and cultural differences precludes critical educational goals, such responses may exacerbate rather than eliminate issues of equity.

The Role of Experience in Teacher Goals and Strategies

Teacher attitudes and knowledge may also account for much of the inequitable treatment of math, science, and technology in the preschool period. The field of early childhood education has struggled for much of the second half of this century to establish a reputation of professionalism. And yet the knowledge base deemed essential for teachers' professional status has been almost exclusively associated with the child study movement and the field of

developmental psychology. Thus the experiences that many early childhood educators bring with them to the classroom in those particular domains reflect their personal histories as learners of math, science, and technology.

Teacher attitudes about specific subject matter also influence their approaches to issues of equity. It has already been noted that experiences in math, science, and technology are generally regarded as less critical to children's development than play-based experiences which contribute to their social and language development. It is also the case that a vast majority of early childhood educators are women, many of whom might identify with the newly defined area of study referred to as "hot cognition" (Ginsburg & Asmussen, 1988). This conceptualization of the interface between emotional anxiety, social supports, and intellectual competence has contributed substantially to our understanding of both the causes of and potential solutions to poor academic performance in other areas as well. This understanding of the relationship between affect, personal relevance, and intellectual activity also helps to explain teacher reluctance to engage in (mathematical or scientific or technological) explorations about which they feel little competence or confidence. The role which teachers assign themselves with respect to children's learning of subjects like mathematics also reflects their beliefs about how children learn (Fennema, Franke, Carpenter, Carey, 1993). Early childhood educators frequently share the view that such domains are best pursued by children through play and other child-initiated activities, eliminating the necessity for purposeful teacher involvement.

Beliefs About How Children Learn

For much of the second half of this century, early childhood professionals have debated the role of instruction in children's learning and development; much of the early childhood

literature has emphasized the value of play in a child-initiated curriculum. This interpretation of children's developmental needs has contributed to a view of the teacher's role which is often limited to preparing the physical environment and then following the child's lead rather than imposing pre-determined educational goals. The emphasis on "concrete" experiences has contributed substantially to the postponement of more abstract discussions of children's scientific understandings and their consequences until the elementary grades (Metz, 1995). These premises of how children can best learn were codified in the form of written guidelines for developmentally appropriate practice, published in response to increasing pressure to "push down" formal academic instruction into the preschool age period (Bredekamp, 1987).

The concept of developmentally appropriate practice played a valuable role in drawing educators' and parents' attention to the child development knowledge base, and especially to the role of play in children's cognitive and social development. The concept of developmentally appropriate practice may also have supported teachers' willingness to accept children's choices even when such choices reinforced gender-based or cultural differences in academic interests and efforts. Thus, for example, many early childhood teachers hesitate to interfere with girls' gravitation to the dramatic play area even as the boys lay claim to the blocks, or the non-English-speaking child's preference for solitary play with puzzles over the more verbal and scientific activity associated with the water table. The concept of developmentally appropriate practice has also supported teacher resistance to explicitly incorporate subject matter material such as math or science into the classroom in any way other than through play and hands-on object manipulation.

A recent article, "If we call it science, *then* can we let the children play?" (Goldhaber, 1994) clearly articulates the relationship between constructive play activities and important

scientific constructs. The title also reveals the tension felt by many teachers in attempting to respond appropriately to children's developmental needs as they correspond to academic goals. While the "hands-on" maxim provides (some) children with valuable opportunities to manipulate and explore the characteristics of scientific materials and mathematical concepts, teacher hesitancy to provide more systematic opportunities for children to reflect upon their ideas and their work makes it less likely that such play-based experiences will lead to significant conceptual change. This minimalization of the teacher's role is supported by the belief that children learn at their own pace, when in fact sometimes it's the adults who are moving slow.

So What's the Good News?

Up to this point, the discussion has focused on the more problematic aspects of achieving equity in classrooms where teachers struggle to respond appropriately to the diverse needs, interests, and capabilities of children, to balance developmental goals with academic expectations, and to confront subjects about which they feel little personal or professional commitment. The final section of this paper considers the challenge of equity from a more optimistic point of view, based on recent advances in our understandings of how children learn and a reconceptualization of the early childhood curriculum.

Learning as a Social Process

Researchers in anthropology, psychology, and education have expanded prior conceptions of the child's solitary construction of knowledge to emphasize the role of the sociocultural environment in children's learning. Contemporary child development theory highlights the relational processes by which children and adults alike acquire the knowledge, skills, and attitudes deemed normative and desirable within particular sociocultural contexts. Summarized most often

as a theory of social constructivism, this perspective regards learning as both a social and cognitive process dependent upon interpersonal exchanges and optimally challenging tasks to complete and ideas to contemplate (Berk & Winsler, 1995).

This new theoretical paradigm supports the premises laid out earlier in this discussion, primarily that children's knowledge of math, science, and technology--like any aspect of children's learning--is informed, influenced, and judged by the sociocultural contexts and social exchanges that characterize their lives. Even very young children learn what is important, tolerated, and expected as they observe and participate in early educational experiences. Thus gender role stereotypes, ethnic identity, and self image as a learner are among those understandings that develop during the period of early childhood (New, 1998). And yet research also suggests that young children have the cognitive capacity to understand the difference between what people *can* do and what they *usually* do (Meece, 1987).

These theoretical premises have significant implications for the role of early schooling in the formation of skills and knowledge as well as attitudes and dispositions regarding math, science, and technology. Research on the role of social processes in early learning in math, science, and technology makes moot the presumed need to choose between responding to children's social versus intellectual or academic needs. Rather, studies on children's early number development illustrates the interplay between social, intellectual, and developmental processes (Saxe, Guberman, & Gearhart, 1987). The importance of personal relevance and social support have been identified as critical to the development of children's concept formation in mathematics (Ball & Wilson, 1996), as well as their interest in science (Jeffe, 1995) and computers (Char & Forman 1994). Indeed, the computer is now understood to provide a unique

unique opportunities for children's learning (Clements, 1994) of technological skills as well as literacy, math, and science (Wright & Shade, 1994). The benefits of social negotiations and collaborative learning have been demonstrated in research on the teaching and learning of science (Julyan & Duckworth, 1996) and mathematics (Saxe & Gearhart,1988). Such studies support theoretical understandings of the role of both individual and social processes (Shapiro, 1994) and new interpretations of the domains themselves, with knowledge negotiated through social exchanges within particular sociocultural contexts (Forman, 1993).

Such research supports the role of peers and teachers in facilitating instruction in math, science, and technology, and the role of approrpriate educational opportunities in these domains for other aspects of children's development. For example, we now know that children with emotional or behavioral disabilities can learn about cause and effect in their joint science activites with more capable others, while children with cognitive impairments benefit from experiences requiring active thinking and reasoning about problems that matter to them. Students with physical or sensory impairments are highly motivated to improve their abilities to observe natural phenomena using all of their available senses (Mastropieri & Scruggs, 1995). This body of research supports the notion that children of all abilities take clues from the larger environment regarding what is important to learn.

These advances in our understanding of how children learn have significant implications for the role of the early childhood educator in the early childhood curriculum. Revised interpretations of developmentally appropriate practices (Bredekamp & Copple, 1997) now make specific reference to the critical importance of teacher observations about what children know and are ready to learn, and the nature of various forms of teacher assistance to facilitate the child's

exploration with new materials, concepts, and conflicts. The theoretical concept of guided participation has blurred the distinction between teacher-directed and child-sensitive pedagogy.

Reconceptualization of the Early Childhood Curriculum

The early childhood curriculum has been described as integrated, emergent, negotiated, and convergent (New, 1998). Within all of these definitions, children are considerably more likely to achieve goals that adults set for them when the content of new knowledge is personally meaningful, contextually relevant, and builds upon rather than replaces existing competencies (Mallory & New, 1994b). This interpretation of curriculum places a heavy emphasis on the role of the teachers, who have the responsibility of insuring that children have opportunities to learn from one another as well as ample motivation to revisit their understandings and reflect critically on their own and each other's ideas. This interpretation also requires that teachers, too, see themselves as students of children's learning and development.

Expanded conceptions of developmentally appropriate practice emphasize the importance of connecting curriculum content with the larger context in which the child lives. Experiences that utilize mathematical concepts, scientific problem solving, and computer technology can not only demonstrate relevance to other school-based aspects of children's lives; they can also create occasions in which children can take on the role of critical thinking, prediction-making, and problem solving. The challenge in promoting competence in the skills and knowledge deemed critical by the larger culture for children who are culturally or linguistically diverse is to convey the usefulness of such knowledge to the children, helping them to gain access to opportunities and resources otherwise unavailable (Delpit, 1995), even as they are also encouraged to explore and express their own specialized knowledge (Phillips, 1994). For children attempting to bridge two

worlds, the role of the teacher is to embrace both realities, modeling the acceptance of diverse forms and sources of competence.

Discussions of equity in math, science, and technology are typically limited to consideration of the fairness of access and opportunities to participate in activities related to those domains. And yet, this reconceptualization of the early childhood curriculum also utilizes math, science, and technology to address attitudes and practices associated with issues of equity. Science, for example, provides a wonderful opportunity to utilize cooperation and problem-solving skills as small groups of children test their capacities to generate and test hypotheses. Children struggling to utilize mathematic concepts to make classrooms decisions can also be encouraged to consider the extent to which numerical advantage translates into fair play. In Reggio Emilia, an athletic project on the long jump ultimately inspired children to debate the nature of gender competencies, the mathematical interpretation of a handicap, and a competence-friendly means of measuring the distance achieved by boys and girls of different ages and abilities. Such opportunities for critical analysis support children's comprehension of the conceptual bases of mathematical computation as well as their efforts to disentangle numerical worth from social meanings (Ball & Wilson, 1996). Far too often, teachers presume that children have neither the interest nor the ability to respond to such socially complex issues, when, in fact, some of children's most serious engagement takes place when they pursue moral dilemmas behind the observation that "our school's not fair!" (Pelo, 1997).

As children engage in scientific processes of observation, hypothesis generating and testing, they can be challenged to confront their own understandings with those of their peers and to engage in deliberations on topics of both social and intellectual significance. Such experiences

contribute not only to conceptual changes in scientific and mathematical thinking, but can give children an increased appreciation of the value of these human competencies as a means of responding to their daily lives and contributing to the advancement of their own thinking and their relationships to each other.

Conclusion

This reconceptualization of the early childhood curriculum is based not only on new understandings of how children learn, but what they need to learn for life in a pluralistic democratic society. Just as it is increasingly vital that children acquire conceptual understandings in math, science, and technology, so too is it essential that children begin to comprehend the role that such knowledge plays in a contemporary democratic society. While many might claim that such an agenda is far from the reach of three-to-five-year-old children, this interpretation of an early childhood curriculum assumes that, just because teachers ought to begin where children are, "beginning there has never implied staying there" (Wright, 1965, p. 34).

Nineteen years ago it was suggested that educators already knew enough to successfully teach all children, and that it was primarily a question of "how we feel about the fact that we haven't so far" (Edmonds, 1979, p. 22). Perhaps this confidence in the knowledge base of the profession was prematurely optimistic, given the changes in our understandings since that time. Today, however, it does seems that we do know a great deal about what we ought to be doing better.

Early childhood educators have the opportunity to make an immediate difference in at least a portion of the life (several hours a day) of a young child. Successful early childhood programs have also demonstrated their potential to make a difference in the continuing lives of the

children and their families "Programs that work" for minority and impoverished children in the U. S. act upon the theoretical premise to connect with children's lives; on the political premise to advocate for their well-being; and on the ethical premise to contribute to parents' abilities to support the learning and development of their children (Barnett & Boocock, 1998). Families of young children must be involved in the determination and the processes of incorporating such educational goals as emergent competencies in math, science, and technology in the early childhood curriculum. To make this happen will take more than an increase in professional development and parent education activities designed to teach them all how to use the internet.

The bigger question of equity in educational resources and opportunities is a dilemma in which the simply acknowledgement of the problem may be one of the greatest challenges. At the least, we must somehow face up to the fact that the schools "mirror inequities in the surrounding society and many people want to be sure that they continue to do so" (Goodlad, 1984). This ideology of "diversity at a distance" (Wells & Serna, 1996) threatens any meaningful effort to close the education gap in American society.

This paper began with an acknowledgement of the period of early childhood as ripe for development and vulnerable to neglect. The societal context of inequities in the classroom calls for a more explicit acknowledgement of the relationship between our hope for more equitable and effective educational responses to children's learning of particular subject matter and our need for more collective commitment to young children. As we approach the end of the 20th century, we are witness to an explosion of knowledge about the real and potential competencies of young children. Perhaps the biggest challenge of the next century will be to actualize our own potentials as adults by better advocating on their behalf.

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